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New records of *Pigrogromitus timsanus* Calman, 1927 (Callipallenidae, Pycnogonida) for the South Atlantic

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Abstract
Pigrogromitus timsanus Calman, 1927 is a species of pycnogonid that has a broad world distribution and belongs to a monotypic genus. Although this species was recorded for the first time in the Southern Atlantic from the port of Natal, state of Rio Grande do Norte, this record appeared in the grey literature, has gone unnoticed, and to our knowledge, the specimens are not available for study. Based on materials in the Paulo Young Invertebrate Collection at Universidade Federal da Paraíba, we provide further proof of the presence of *P. timsanus* in the Southern Atlantic. We also provide an updated account on the worldwide distribution of this species.

Key words
Brazil, exotic species, shallow water, Pantopoda.

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Introduction

Pigrogromitus Calman, 1927 is a monotypic genus of pycnogonid of uncertain systematic position. *Pigrogromitus timsanus* Calman, 1927 varies little morphologically, being characterized by a robust habitus, the presence of tubercles on the trunk segments and on the cheliphores, the presence of 2 articles on the scape, and the presence of functional chelae (Child 1988, 1992, Nakamura and Child 1988, Arango 2003). The body shape of this species is quite similar to that of species of *Pycnogonum* Brünnich, 1764 (Arango 2003).

Pigrogromitus timsanus is a shallow-water species. It has been recorded from a large variety of substrates, such as rocky bottoms (Child 1982, Müller and Krapp 2009), in association with port constructions (Stock 1974), on algae, on *Rhizophora*, or on seagrass (Stock 1974, Bamber 1997, Müller and Krapp 2009). It is associated with a number of animal groups such as hydroids and corals (Child 1979, 1992), barnacles (Reimer 1976, Müller 1990a), and *Lybia tesellata* (Latreille in Milbert, 1812) (Nakamura and Child 1988). This species has a broad, worldwide distribution and has been recorded in almost all intertropical oceans (Stock 1992, Bamber 1998, Arango 2003). It is considered to be circum(sub) tropical (Zenetos et al. 2010).

In an abstract of a scientific meeting, *P. timsanus* was recorded for the first time in the Southern Atlantic by Ferreira et al. (2010) in the port of Natal, state of Rio Grande do Norte. This record went unnoticed

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in the zoological literature, and to our knowledge, the specimens on which this earlier record was based are unable for study and verification The Southern Atlantic had been considered to be the only intertropical area in which this species did not occur. Our aim is to publish the record of *P. timsanus* for the Southern Atlantic and for Brazil, based on new material collected in the state of Paraíba. This expands this species' known distribution to the state of Paraíba and the Southern Atlantic.

Methods

Specimens, collected in 2007 and 2012 by the Team of Project Biodiversity of Polychaetes (PBP), were found in the Paulo Young Invertebrate Collection, at the Universidade Federal da Paraíba (UFPB.PYC). Identification was based mainly on Calman (1927) and Müller and Krapp (2009). The third leg and the oviger were prepared on permanent slides in Hoyer medium for identification. Specimens were drawn using the stereomicroscope Nikon SMZ800 and the microscope Olympus U-5RE-2. The material was deposited in CIPY, Universidade Federal da Paraíba (UFPB). The drawings were edited using GIMP v. 2 and maps were made with QGIS v. 2.18.16.

Results

Pigrogromitus timsanus Calman, 1927

Figures 1A–E, 2A–B

Pigrogromitus timsanus Calman 1927: 408–410, fig. 104a–f.
Clotenopsa prima Hilton 1942: 52–53, fig. 8.

Material examined. Brazil. Paraíba: Barra de Mamanguape, 11 Aug. 2010, coll. PBP (UFPB.PYC-002, 1♂ and 1♀). Paraíba: Coqueirinho, 28 Aug. 2012, coll. PBP (UFPB.PYC-146, 1♀). Rio Grande do Norte: Diogo Lopes, 10 Nov. 2007 (UFPB.PYC-261, 1♂).

Identification. Animal of medium size (ca 1.20 mm). Trunk robust, completely segmented, with a rounded tubercle, slightly broader than long, near distal margin of each segment. Terminal setae on tubercles 1–3, absent on last tubercle. A small tubercle present above insertion of cheliphores, with apical setae (Fig. 2A). Lateral processes separated by a gap measuring less their diameter, with distal margin expanded, and distal apical setae. Ocular tubercle small, rounded and trilobed, broader than long (Fig. 2A). Eyes of medium size. Proboscis robust, bulbous, with narrow base, and slight constriction in median region (Fig. 2B). Abdomen pointing backwards, horizontal, elongate, not articulated with the body, reaching to middle of coxa 2, and with small scattered setae (Fig. 1A, B).

Cheliphores lateral to proboscis, slightly longer than half length of proboscis. Scape of cheliphore with 2 articles, the second being twice as long as first (Fig. 1C). Second article with 2 small setae. Chelae small, with fingers longer than palm, strongly curved. Oviger with 10 articles and 1 terminal claw (Fig. 1D). Fifth article longer than remaining articles, sixth and seventh articles subequal. Remaining articles diminishing gradually in size. Setae bifurcate beginning from the third article. Sixth article with a robust spine on outer margin. Seventh article with 2 spines on inner distal margin, eighth to tenth articles with 1 spine along this margin.

Legs robust, with sparse setae (Fig. 1E). Coxa 1 with dorsal setae. Setae bifurcate from coxa 2 onwards. Coxa 2 longer than coxae 1 and 3. Gonopores in all legs of the females and in the last 2 pairs in males. Femur twice as long as coxa 3 with a small dorsal tubercle on distal margin, and setae concentrated on proximal ventral region. Tibiae 1 and 2 with 2 expansions, 1 close to proximal border, the other close to distal border. Tibia 2 shorter than tibia 1, with a seta on each elevation. Tarsus small, with setae concentrated on inner margin. Propodus longer than tibia 2, with a row of dorsal setae and 3 rows of setae on sole. Heel absent. Main claw more than 1/2 length of propodus, strongly curved.

Distribution. Presently this species is considered circum(sub)tropical (Zenetos et al. 2010) and has been recorded in Brazil from Paraíba and Rio Grande do Norte (Fig. 3), as well as Curaçao (Stock 1974), Colombia (Müller and Krapp 2009), Atlantic and Pacific Panama (Reimer 1976), Atlantic and Pacific Mexico (Child 1979), Belize (Child 1982), Florida (USA) (Hedgpeth 1948), Hawaii (Hilton 1942), Israel (Lipkin and Safriel 1971), Suez Channel (Calman 1927), Madagascar (Arnaud 1972), Reunion Island (Müller 1990b), Oman (Stock 1992), Pakistan (Stock 1968), India (Stock 1968), Sri Lanka (Müller 1990a), Singapore (Lucena and Christoffersen 2018), Australia (Staples 1982), New Caledonia (Stock 1991), Indonesia (Nakamura and Child 1990), Philippines (Child 1988), Hong Kong (Bamber 1997), and Japan (Nakamura and Child 1988) (Fig. 4).

Morphological variations. Despite its circumtropical distribution, few morphological differences are mentioned in the literature. Other than differences in size, from 1.2 mm (this work) to 1.9 mm (Calman 1927), the lateral processes are indicated as being either contiguous (Hilton 1942, Staples 1982, Arango 2003, Müller and Krapp 2009) or separated by about half the width of the lateral processes (Calman 1927, Hedgpeth 1948, this work).

The specimens we studied varied little in relation to the original description, with only small differences, such as the presence of setae on the lateral processes, strong spines on the last 4 articles of the oviger (both illustrated but not described by Calman 1927), and a tubercle on the distal margin of the femur, which varies in size in the examined specimens, as similarly reported by Arango (2003). Furthermore, our specimens have a proboscis that is diagonal relative to the trunk, rather than projected anteriorly, but this may be due to the process of fixation. The specimen from Rio Grande do Norte had bifid dorsal tubercles, similar to those in Bamber

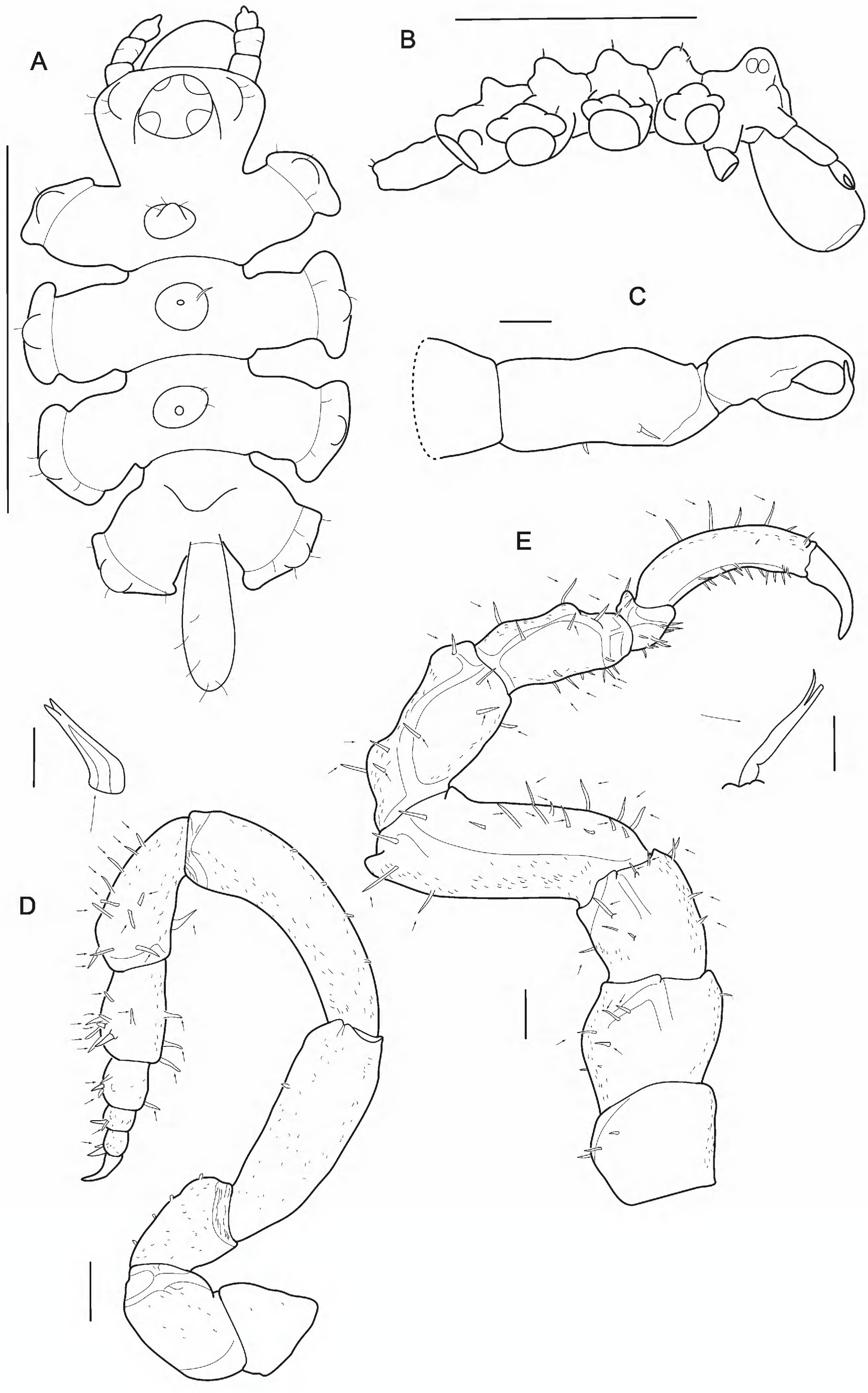

Figure 1. *Pigrogromitus timsanus* (UFPB.PYC–002) **A–E.** Male. **A.** dorsal view. **B.** lateral view. **C.** cheliphore. **D.** oviger. **E.** 3rd leg. Scale bars: A, B = 1 mm; C = 0.05 mm; D, E = 0.1 mm. Details = 0.025 mm.

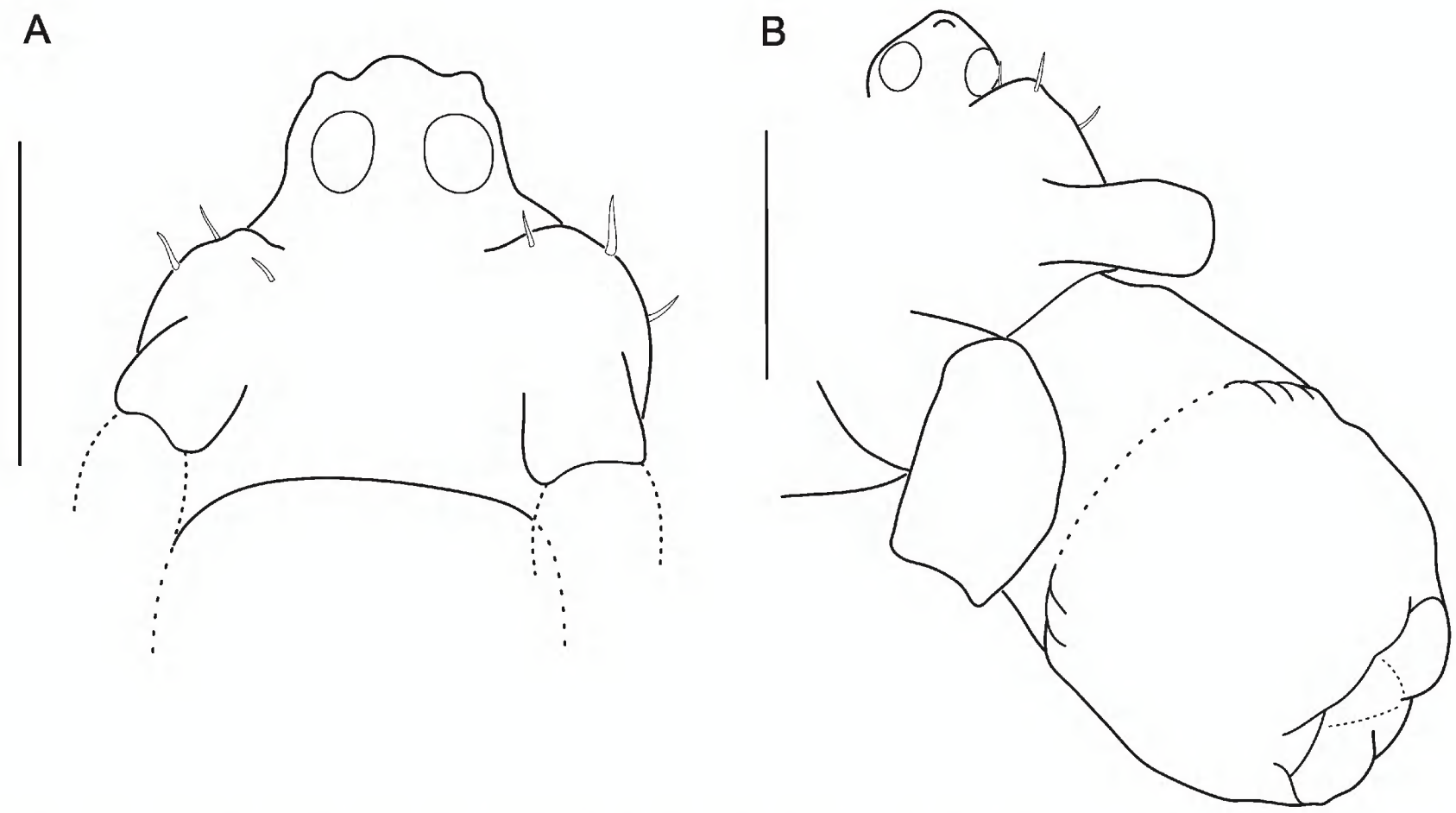

Figure 2. *Pigrogromitus timsanus* (UFPB.PYC–002), male. **A.** frontal view of cephalic segment. **B.** Lateral view of proboscis and cephalic segment. Scale bars = 0.5 mm.

(1997), while the specimens from Paraíba had rounded tubercles. We also observed differences in the total body length; the specimen from Coqueirinho (Paraíba) was the smallest (1 mm), followed by the specimens from Barra de Mamanguape (Paraíba) (♂ 1.3 mm and ♀ 1.2 mm) and Rio Grande do Norte (1.5 mm).

We also highlight the following morphological characters, which were previously mentioned for this species and were present in all specimens that we examined: (1) ocular tubercles trilobate, rather than just rounded, as described and illustrated previously by Hilton (1942); (2) presence of lateral tubercles above the insertion of the

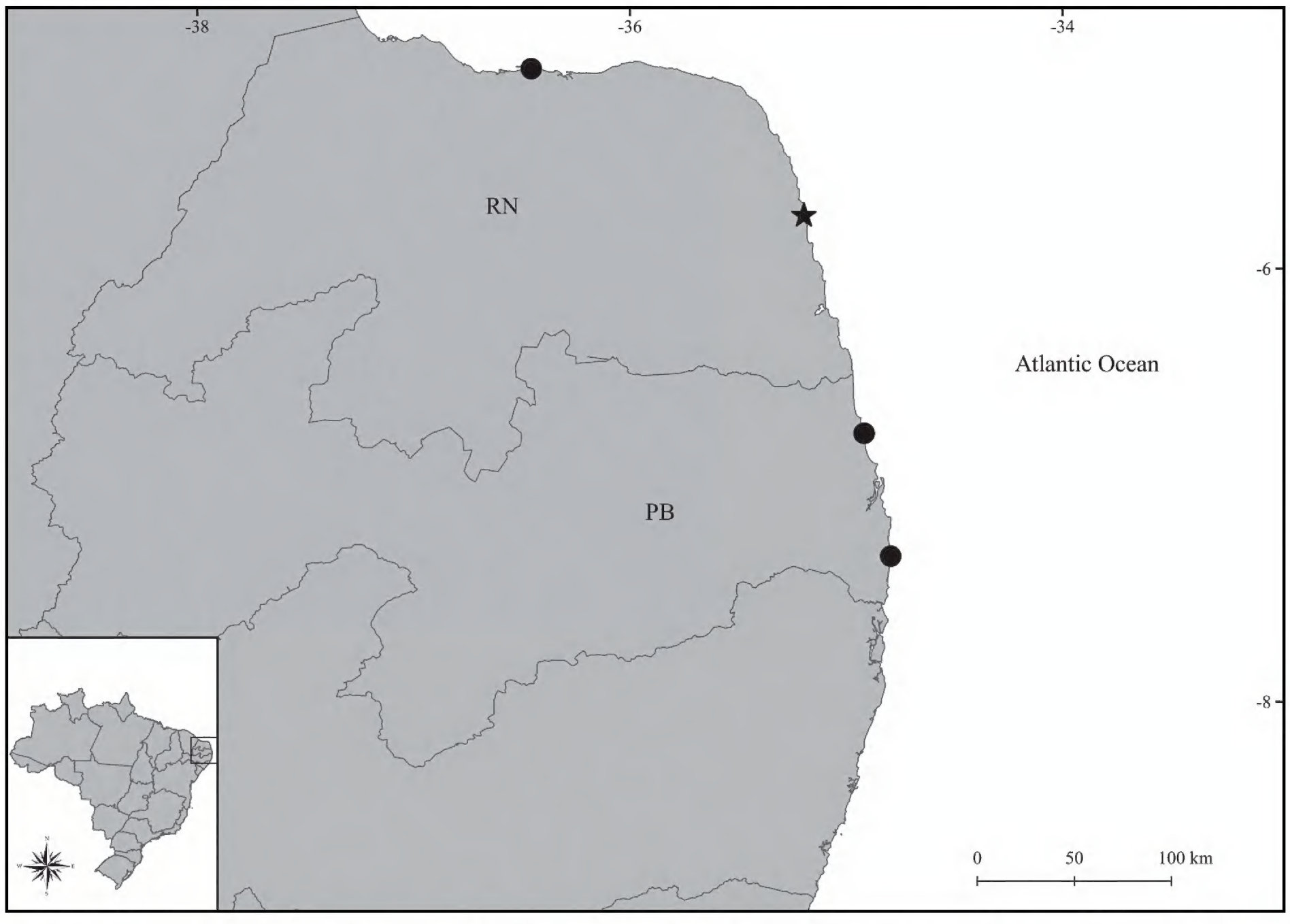

Figure 3. Map of the areas where *Pigrogromitus timsanus* were collected. Circles = in the present record. Star = record by Ferreira et al. (2010). State abbreviations: PB = Paraíba; RN = Rio Grande do Norte.

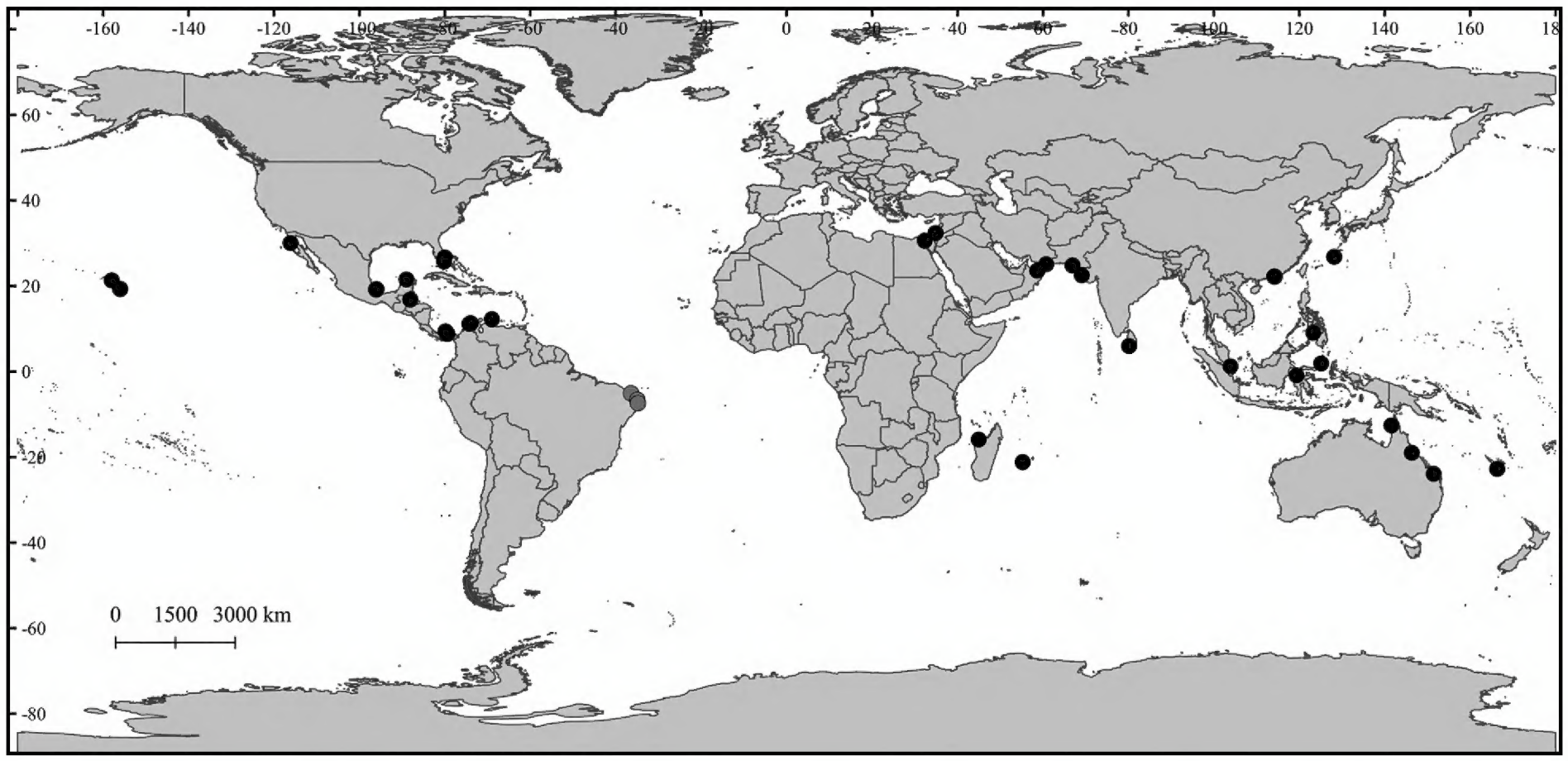

Figure 4. Map of known distribution of *Pigrogromitus timsanus* around the world. Black circles = previous records. Grey circles = new records.

cheliphores, with small apical setae; and (3) the presence of birfurcate setae not only on the ovigers, as described by Müller and Krapp (2009), but also on all the articles of the legs, with the exception of coxa 1.

Discussion

Although *Pigrogromitus timsanus* was recorded from the port of Natal, state of Rio Grande do Norte, Brazil by Ferreira et al. (2010) in an abstract of a scientific meeting, this grey-literature record was overlooked. We have been unable to obtain the material examined by Ferreira et al. (2010) and were unable to verify their specimens. For this reason, we consider it important to confirm the presence of *P. timsanus* in the Southern Atlantic, and thus, we provide documentation of other specimens from Paraíba and Rio Grande do Norte. Following the reasoning of Ferreira et al. (2010), we believe that *P. timsanus* is an exotic species in Brazil, but one that has a low invasive potential. Our records do not come from ports but are in relative proximity to ports (40 km from Cabedelo in Paraíba and 200 km from Natal in Rio Grande do Norte), and thus we believe that *P. timsanus* may have been introduced to Brazil by ships. These records, not immediately within ports (40 km from the nearest port) might indicate that this species is beginning to disperse along the eastern coast of northeastern Brazil.

Pigrogromitus timsanus was characterized as "pseudoindigenous" for the Indo-Pacific (Carlton 2009), the area where this species is most recorded (Coles et al. 1999, Zenetos et al. 2005). It is considered exotic for all the remaining regions (Stock 1992). It is believed that ships are responsible for the introduction of this species around the globe (Stock 1992). This hypothesis is quite plausible considering the variety of substrates on which *P. timsanus* occurs (Stock 1974, Child 1979, Müller and Krapp 2009) and its many occurrences in port areas (Coles et al. 1997, 1999).

Despite the absence of an active dispersal form (Bamber 1998), *P. timsanus* is widely distributed around the world. There is little information regarding its original distribution (Carlton and Eldredge 2009). *Pigrogromitus timsanus* is one of the few species able to survive inside the Panama Channel (Child 1979) and the Suez Canal (Gusso and Lattazani 2003).

With the records documented here, *P. timsanus* now known to occur in all intertropical regions of the globe. Temperature is apparently the main limitation for the further expansion of this species' range (Bamber 1998), and the eastern Mediterranean and the Suez Canal are the only areas north of the Tropic of Cancer where it occurs.

We adopt the opinion of Hedgpeth (1947) who placed *Pigrogromitus* in Callipallenidae instead of in Ascorhynchoidea *incertae cedis*, as proposed by Bamber (2007). We believe that the tendency to displace the proboscis laterally, either more subtly in *Callipallene* Flynn, 1929, *Parapallene* Carpenter, 1892, and *Cheilopallene* Stock, 1955 or more strongly in *Neopallene* Dohrn, 1881 and *Cordylochele* Sars, 1888, is a good indication of this relationship (as pointed out by Clark 1963). *Bradypallene* Kim & Hong, 1987, for example, shares a greatly resembles *P. timsanus*, which is a good indication of this relationship (again as remarked by Clark 1963).

In addition, Child (1979: 46) observed that in juveniles of *P. timsanus* "the ovigers become fully developed at the same time that the last legs reach full development." This developmental pattern is considered uncommon within Pycnogonida and is similar to the so-called "attaching larva" (Bain 2003) and for the type 5 developmental pattern (Brenneis et al. 2017). In this pattern the ovigers appear in the sixth instar, when the last pair of

legs still have only 6 articles, and become fully formed in the seventh instar with the final development of the last pair of legs. Although this pattern is not exclusive of Callipallenidae (it is also found in Nymphonidae and Pallenopsidae) (Brenneis et al. 2017), if confirmed, it represents another character state to place *P. timsanus* in or near the Callipallenidae.

Future phylogeographic mapping may be able to give a clue as to the relationship of this species within the Callipallenidae. Developmental studies are necessary to place this species more precisely within the Pycnogonida. A phylogenetic analysis should be able to confirm this species' placment in Callipallenidae, as originally suggested by Child (1979).

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Authors' Contributions

RAL analyzed the specimens, made the map, and identified and drew the specimens. Both authors wrote the note and corrected the final version of the manuscript.

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